Hooke's Law Lab (spring constants)

SPH4U

Procedure:

1. Measure the mass m_s of a large spring.

2. Determine the range of mass values that you will investigate. The range of masses should correspond to a wide range of spring extensions. Please <u>don't overstretch</u> the spring.

3. By hanging mass M on the spring and reading the position of the mass hanger against a meter stick, you are going to determine the spring constant k. Be sure to use SI units. It is up to you to decide how many different values of M to use, and by how much to increase M for each measurement. Note that there is no x value for M = 0, and that the origin of the meter stick has no particular meaning. These are not real problems, for reasons given below. However, you should not move the meter stick after you start making measurements!

4. Make a graph of F_r (vertical axis) vs. x (horizontal axis). [Recall that $F_r = Mg$ for the spring when it is in equilibrium.] Determine the slope of your best line through the data. This slope should correspond to the spring constant k in N/m. Note that the slope does not depend on where you placed the origin of the meter stick. Also note that your first few data points might not be on a straight line. If this is the case, you may ignore these points in drawing your best line.

5. Take a different type of spring. Stretch it a little to get a feel for the strength of the spring. Do the same for the first spring you measured. Starting in step 6 you will make measurements of the force in the second spring. But first, make a prediction of what you expect to find. What will the graph of F_r vs x look like for the second spring relative to the first spring? How will the spring constant of the second spring compare to the spring constant of the first spring? Be sure to identify which spring is which with a clear description of the two springs.

6. Repeat steps 1 through 4 for the second spring.

7. Compare your results with your predictions. What does the spring constant tell us? That is, what are the characteristics of springs with large spring constants compared to those springs with small spring constants?

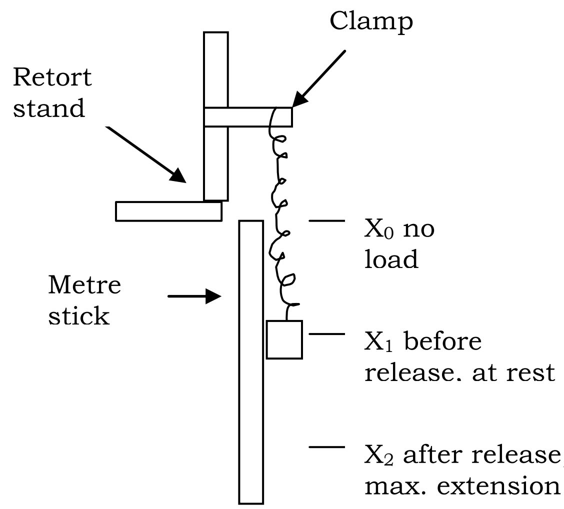
8. For one spring calculate the work done by the gravitational force as it stretched the spring (area <u>under</u> F-x graph). Do this by first estimating the work done by the force between successive measurements of the force and then by adding together these individual contributions to the total work. Compare this value to the predicted by the relationship $W = ½kx^2$.

Conservation of energy in an elastic spring

SPH4U

Purpose: what are the relationships between the gravitational potential energy (E_g) of a suspended mass and the elastic potential energy (E_e) in a stretched spring?

Procedure:



1. Set up the apparatus as illustrated at right. Use the same spring as you used last in the Hooke's law investigation.
2. Adjust the metre stick so that its zero point is adjacent to the lower end of the unloaded spring (x_0).

PART A

3. Attach a 0.5 kg mass to the spring and lower it gently so that the spring is stretched to one-half the amount that the mass would normally stretch it (see previous investigation). Designate this position as x_1, and then release the mass so that it falls freely. Note the maximum extension of the spring (x_2) by placing a pencil next to the metre stick.
4. Describe (in words) the types of energy in the spring-mass-earth system at points x_0, x_1 and x_2.
5. Determine the loss in gravitational potential energy (ΔE_g) of the mass as it falls from x_1 to x_2.
6. Determine the elastic potential energy (E_e) at positions x_1 and x_2. Use the relationship $E_e = \frac{1}{2}kx^2$. Calculate the gain in elastic potential energy ΔE_e as the spring stretches from x_1 to x_2. Compare this with the loss in gravitational potential energy (ΔE_g).

PART B

7. Repeat steps 3-6, this time releasing the 0.5 kg mass from a point that represents ¾ of the normal amount of stretch of the spring.

PART C

8. Repeat steps 3-6, this time releasing a 0.20 kg mass from a point that represents one-half of the normal amount of stretch.

PART D

9. Attach a 0.20 kg mass to the spring. Release the mass from the no load position (x_0). Record the maximum extension of the spring (x_m). (you'll need to do this a few times to get an accurate value). Determine he midpoint $x_{1/2m}$ between the extensions x_0 and x_m.
10. Describe in words the types of energy in the spring-mass-earth system at the points x_0, $x_{1/2m}$ and x_m.
11. Calculate the loss in gravitational potential energy as the mass falls from x_0 to $x_{1/2m}$.
12. Calculate the gain in elastic potential energy as the spring stretches from x_0 to $x_{1/2m}$.

13. Compare the loss in gravitational potential energy with the gain in elastic potential energy, from x_0 to the midpoint $x_{1/2m}$. Account for any differences.

14. What types of mechanical energy does the system possess when the mass is at the midpoint? Determine the amount of each type. Finally, determine the velocity of the mass at that point.

The following tables might help to categorize your data.

	Mass (kg)	x_1 (m)	x_2 (m)	Δx (m)	ΔE_g =mgh or =mgΔx (J)	$E_{e,1}$ =1/2kx_1^2 (J)	$E_{e,2}$ =1/2kx_2^2 (J)	$\Delta Ee=E_{e,2}-E_{e,1}$ (J)
Part A	0.5							
Part B	0.5							
Part C	0.5							

	Mass (kg)	$x_{1/2m}$ (m)	x_m (m)	Δx (m)	ΔE_g	ΔEe	ΔE_g-ΔEe (J)	E_k (J)
Part D	0.2							